

Atmospheric corrosion process of low alloy steels under seashore environment

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Abstract

In atmospheric corrosion study of iron and steels, an evaluation of the corrosion behavior is difficult, because the conventional electrochemical method can not be applied to the study. Under thin water film layer, the phenomenon of corrosion on steels is different from the behavior in the solution. Atomic force microscopy (AFM) measurements were performed for the investigation of the rusting process of low alloy steels. The high sensitivity profile was determined by AFM for steel surface with droplets of artificial seawater following the exposure to corrosive atmosphere. Simultaneously with AFM surface potential on iron was detected using a Kelvin force microscope (KFM) system during rusting process. The efficiency of alloy elements on atmospheric corrosion morphology was investigated by pH distribution measurement using scanning chemical microscope (SCHEM).

Pure iron and Fe-Cr and Fe-Ni low alloy steels were used as experimental samples. A droplet of artificial seawater and the sea salt particle attached on the sample. After that, the rust growth process was observed in the fixed relative humidity. Atomic force microscope (AFM) was used for the observation of initial rusting process on the iron and the steel under the atmospheric corrosion condition. Scanning chemical microscope (SCHEM-100) on the marketing (HORIBA Co. Ltd.) was used for the surface pH distribution measurement. Schematic diagram of the pH measurement by SCHEM is shown in the Fig.1. It contacts a sample with the sensor for the pH measurement which semi-conductor, insulator was spread in and which was put together through the agar as an electrolyte, and laser light is irradiated on the surface of the sensor. Sensitizing electric current (photocurrent) due to the optical irradiation flows as a character of the semi-conductor part in the laser irradiation part. The pH value was decided by the relation between the bias voltage and photocurrent.

The rust on the iron and the low alloy steel was formed in the filiform shape and had the height of about 2μm. AFM/KFM image of rusting profile shows that the rust on low alloy steels was growing under atmospheric corrosion environment, at the part of less noble potential.

The corrosion morphology of pure iron and Fe-Ni low alloy steel was general corrosion. On the other hand, in the case of Fe-Cr alloy, pitting corrosion was produced on the surface under the rust layer. Although the rusting formation shape of all steels was the same as the filiform corrosion type, the surface condition of the Fe-Cr alloy was different from the iron and Fe-Ni alloy. Both Cr and Ni addition also had the effect on the decreasing the corrosion rate in the atmospheric corrosion environment.

Figure 2 shows the pH distribution of the corroded surface on the low alloy steels after 30 min and 2 hours. The pH distribution on the Fe-Ni low alloy steel was spread for the homogeneity in all the area after 1 hours.

In the case of Fe-Cr low alloy steel, after 1 hours the heterogeneous pH distribution was appeared in this figure. As the surface pH profile became heterogeneous, the corrosion on Fe-Cr alloys under the atmospheric corrosion environment progresses for the heterogeneity. Therefore, the corrosion morphology was caused by the pH localization with the dissolution of alloy elements. It can be explained by the hydrolysis equilibrium as it can be known in the case of the stainless steel. As Fe and Ni anodic dissolution did not make the pH decline, the corrosion of iron and the Fe-Ni alloy was general corrosion. When the anodic dissolution of Cr was carried out, it is easy to decline pH and severe condition was achieved at the local site. And then the steel contained Cr was produced localized corrosion.

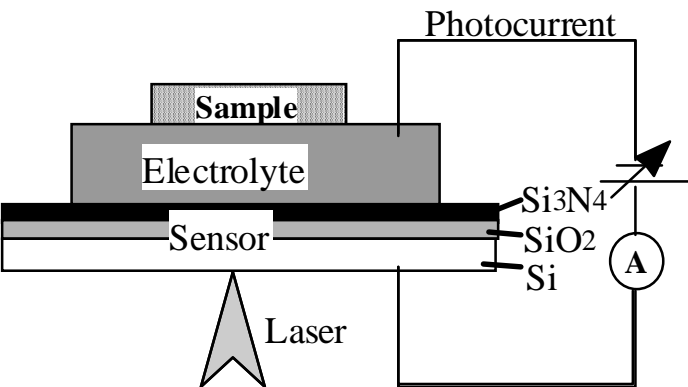


Fig.1 Schematic diagram of SCHEM for pH distribution measurement.

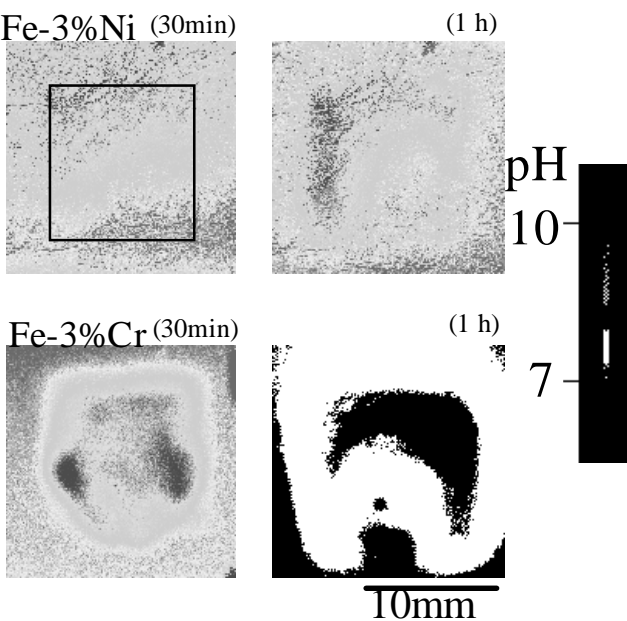


Fig.2 The pH distribution of the low alloy steel (Fe-3mass%Ni, Fe-3mass%Cr) at 30min and 1h during corrosion test.